

of certain corals, the author discusses the classificatory position of the vegetable form. Naming it *Achlya penetrans*, he suggests that it belongs to a group whose life-cycle is complicated by marine and subaerial conditions, and infers that *Achlya*, *Saprolegnia*, *Botrytis*, *Peronospora*, *Empusina*, and possibly *Bryopsis* are so many names of the same organism under these different conditions. Believing in the necessity of an arbitrary name, he prefers that of *Achlya*. Finally an instance of a parasite resembling what is called *Saprolegnia ferax*, Ktz., in a littoral coral is given.

II. "On the Calculation of the Trajectories of Shot." By W. D. NIVEN, M.A., F.R.A.S. Communicated by J. CLERK MAXWELL, F.R.S., Professor of Experimental Physics in the University of Cambridge. Received March 24, 1876.

(Abstract.)

The solution of the equations of motion of a shot is necessarily approximate, because the resistance cannot be expressed by a single exact formula, and, moreover, there are very few formulæ which are capable of affording an easy solution. The results which Hutton obtained by means of the ballistic pendulum were exhibited in the shape of a simple formula; and in like manner Piolet and Didion, who also used the ballistic pendulum, reduced their results, and were able to give simple formulæ. No one can doubt, however, that, in point of accuracy and extent of information, their results are inferior to those which Mr. Bashforth obtained by means of his chronograph and screens. Now the formulæ which Hutton and Didion gave apply only to spherical shot; and even for that kind of shot they do not agree with Mr. Bashforth's results except for a limited range of velocities. Mr. Bashforth makes no attempt to formulate his results, but produces them in the shape of two Tables, one for spherical shot, the other for cylindrical. The nature of the reductions of his experiments, and the fortunate circumstance that for a large range of values of the velocity the resistance varies nearly as the cube of the velocity, render it convenient to express the resistance in the form μv^3 , where v is the velocity and μ a variable coefficient. In fact, if d is the diameter of the cross section of the shot in inches, and W its weight in lbs., the retardation due to resistance is

$$\frac{d^2}{W} K \left(\frac{v}{1000} \right)^3,$$

where K is a number which is tabulated for every 10 feet of velocity. The question, then, is to solve the problem of the motion of a shot in conjunction and agreement with the Tables for K . The problem is a very important one, not only to the gunner but the gun-maker, there being many practical questions, for example, connected with the dimen-

sions of shot, which could be dealt with more satisfactorily if there existed an easy method of calculating ranges. Mr. Bashforth gives one solution in his treatise, and the object of this paper is to give another.

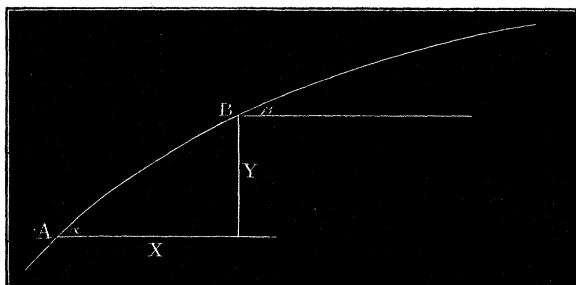
The expressions here proved depend upon three integrals, which may be defined for ogival-headed shot as follows :—

$$V_n = \frac{180g}{\pi} \int_n^{1700} \frac{(1000)^3 dV}{KV^4},$$

$$S_n = \int_n^{1700} \frac{(1000)^3 dV}{KV^2},$$

$$T_n = \int_n^{1700} \frac{(1000)^3 dV}{KV^3}.$$

Of these integrals the two last have been already tabulated by Mr. Bashforth : the first is now given as low as $n=900$. The integrals are calculated between every 10 feet, for which the values of K are given, the arithmetical mean of K over the interval being taken.



Let AB be a portion of the trajectory of a shot ; let the inclinations at A and B be α and β , and the horizontal components of the velocity at the same points p and q . Then it is proved that the inclination $\bar{\phi}$ of the chord AB is approximately

$$\frac{\alpha + \beta}{2} + \frac{p - q}{p} \frac{\alpha - \beta}{6} \text{ in the ascending branch,}$$

and
$$\frac{\alpha + \beta}{2} - \frac{p - q}{p} \frac{\beta - \alpha}{6} \text{ in the descending branch.}$$

If it be assumed that the inclination of motion between A and B has the mean value $\bar{\phi}$, the following four equations constitute the approximate solution of the problem, and the limits of the integrals are such as to make the results from the assumption approximate to the actual case :—

$$V_{q \sec \bar{\phi}} - V_{p \sec \bar{\phi}} = \frac{d^2}{W} D \sec \bar{\phi}, \quad (a)$$

where D is the number of degrees in the difference between the inclinations at A and B ;

$$\frac{d^2}{W} X = \cos \bar{\phi} (S_{q \sec \bar{\phi}} - S_{p \sec \bar{\phi}}), \quad \dots \quad (b)$$

$$\frac{d^2}{W} Y = \sin \bar{\phi} (S_{q \sec \bar{\phi}} - S_{p \sec \bar{\phi}}), \quad \dots \quad (c)$$

$$\frac{d^2}{W} T = T_{q \sec \bar{\phi}} - T_{p \sec \bar{\phi}}, \quad \dots \quad (d)$$

X, Y being the horizontal and vertical distances respectively between A and B, and T the time.

The first equation gives q ; and it will in general be sufficient in that equation to put $\bar{\phi} = \frac{\alpha + \beta}{2}$, because the secant of a small angle varies

slowly. If, however, the angle of projection is large, it will be necessary to operate twice with the equation (a), the first time to determine an approximate value of q , the next time to determine a more accurate value after having obtained an approximation to the correct value of $\bar{\phi}$. In the (b) and (c) equations the more accurate value will be employed in the cosine and sine, which occur as factors outside of the integrals.

As an example of the method, take the case of a shot fired from a 38-ton gun. The following are the data:—Diameter of shot 12·5 inches, weight 810 lbs., angle of projection 3° , velocity 1400 feet, height of muzzle above ground 14 feet.

Let the work be first taken over the whole of the ascending branch. The first thing to do is to find q from the formula (a).

We have

$$\begin{aligned} \log (p \sec 1\frac{1}{2}) &= \log (1400 \cos 3^\circ \sec 1\frac{1}{2}) \\ &= 3\cdot1456812; \\ \therefore p \sec 1\frac{1}{2} &= 1398\cdot6. \end{aligned}$$

From the V_p Table,

$$V_{p \sec 1\frac{1}{2}} = 1\cdot0568.$$

Again,

$$\begin{aligned} \log \frac{d^2}{W} &= 1\cdot2853350 \\ \log 3 &= \cdot4771213 \\ \log \sec 1\frac{1}{2} &= \cdot0001488 \\ &\quad \underline{ 1\cdot7626051} \\ \therefore \frac{d^2}{W} 3 \sec 1\frac{1}{2} &= \cdot5789; \\ \therefore V_{q \sec 1\frac{1}{2}} &= 1\cdot0568 + \cdot5789, \\ &= 1\cdot6357. \end{aligned}$$

$\therefore$ from the V Tables we find

$$q \sec 1\frac{1}{2} = 1290.$$

More accurate value of $\bar{\phi}$:—

$$1^{\circ} 30' + \frac{1398.6 - 1290}{1398.6} \times 30'$$

$$1^{\circ} 32' 35''$$

$$\log \cos \bar{\phi} = \bar{1}.9998445$$

$$\log \sin \bar{\phi} = \bar{2}.4274621$$

$$16429$$

$$\bar{2}.4291050$$

From Mr. Bashforth's Tables for S_0 and T_0 :—

$$S_{1290} = 1920.5$$

$$T_{1290} = 1.3007$$

$$S_{1398.6} = 1355.3$$

$$T_{1398.6} = .8796$$

$$\text{Difference} = 565.2$$

$$.4211$$

$$\log X = 2.7522022$$

$$\log Y = 3.4668672$$

$$\bar{1}.2853350$$

$$\bar{2}.4291050$$

$$3.4668672$$

$$1.8959722$$

$$\bar{1}.9998445$$

$$3.4667117$$

$$\log T = \bar{1}.6243852$$

$$\bar{1}.2853350$$

$$.3390502$$

$$\therefore X = 2929, \quad Y = 78.7, \quad T = 2.183.$$

The projectile having ascended 78.7 feet will have to fall through $78.7 + 14 = 92.7$. In the descending branch we shall again integrate over 3° , because a good deal of the calculation will then have been done for us in the work for the ascending branch.

Our p here is the q of the last arc, so that

$$p \sec 1\frac{1}{2} = 1290;$$

$$\therefore V_{p \sec 1\frac{1}{2}} = 1.6357;$$

$$\therefore V_{q \sec 1\frac{1}{2}} = 1.6357 + .5789 \\ = 2.2146.$$

$$q \sec 1\frac{1}{2} = 1207.4.$$

$$\phi = 1^{\circ} 28'.$$

$$\text{Difference of S's} = 488.1$$

$$\text{Difference of T's} = .3912.$$

$$X = 2529.5$$

$$Y = 64.76$$

$$T = 2.028.$$

The projectile has still 28 feet to fall through.

As an approximation let us put

$$\frac{d^2}{W} \cdot 28 = \sin 3^\circ 20' (S_{q \sec 3^\circ 20'} - S_{p \sec 3^\circ 20'}).$$

We should get

$$S_{q \sec 3^\circ 20'} = 2502.3;$$

$$\therefore q \sec 3^\circ 20' = 1193.0.$$

$\therefore$ using equation (a), $D = 38'.2$.

We may now put

$$X = 28 \cot (3^\circ 19'.1) \\ = 482.8$$

and

$$T = \frac{482.8}{1200} \text{ nearly } .402.$$

Summation of X's:—

$$\begin{array}{r} 2929 \\ 2529.5 \\ 482.8 \\ \hline \end{array}$$

$$\text{Range} = 5941.3$$

Summation of T's:—

$$\begin{array}{r} 2.183 \\ 2.028 \\ .402 \\ \hline \end{array}$$

$$\text{Time of flight} = 4.613$$

The observed range and time of flight were in this particular case 6060 feet and 4.75 sec.

III. "Condensation of Vapour of Mercury on Selenium in the Sprengel Vacuum." By R. J. Moss, F.C.S., Chemical Laboratory, Royal Dublin Society. Communicated by G. JOHNSTONE STONEY, F.R.S. Received March 25, 1876.

In the course of experiments on the electrical conductivity of selenium, a cylindrical bar of this substance in the vitreous state was enclosed in a glass tube which was attached to the exhaust-tube of a Sprengel pump. The bar of selenium was 45 millims. long and 3.5 millims. in diameter. Platinum wires were attached to the ends of it and passed through the sides of the glass-tube. The tube was exhausted, and allowed to remain attached to the pump for four days. It was now found that the selenium had acquired a conductivity greatly exceeding that of the pure element in its most highly conducting condition. The experiment was repeated with the intention of observing the time required to produce conductivity. In forty-two hours the needle of a highly sensitive gal-

